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OPTICAL CHARACTERISTICS OF TROPICAL TREE-LEAVES AND BARKS.

III. CARDEIRO (Scleronema micranthum Ducke), UCUÚBAS (Virola ssp.), BREUS (Protium ssp.) AND MATÁ-MATÁS (Eschweilera ssp.)

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The trees :

CARDEIRO (Scleronema micranthum Ducke — Bombacaceae) is well known in the terra firme tropical rain forest in the surroundings of Manaus. According to Rodrigues (1967), a preliminary forest inventory along the Manaus-Itacoatiara Road, covering an area of about 137 000 ha, counted Cardeiro second in abundance (3.4 trees/ha), considering diameter classes (DBH) above 25 cm.

UCUÚBAS (Virola ssp. — Myristicaceae) are widespread all over the eastern half of the Amazonian Hylaea.

BREUS (Protium ssp. — Burseraceae), mostly medium-sized trees, are known in Amazônia and various other states of Brazil.

MATA-MATÁS (Eschweilera ssp. — Lecitidaceae), following Rodrigues, rank first in abundance (6.5 trees/ha) in the forest inventory area stated above.

Detailed information on all 4 species is presented in Loureiro, A. A. + Freitas da Silva, M. (1968).

The sites:

At Reserva Florestal Ducke, a Forest Pilot Scheme of the Instituto Nacional de Pesquisas da Amazônia (INPA), located at km 26 of the Manaus-Itacoatiara Road (AM-010), an almost unthinned high tropical rain forest strip was chosen for study.

3 different sites were surveyed:

I. A low ground forming small strips on either side of a rain forest rivulet. Sandy soils predominate. Although seasonal variations are common, the water table is remarkably high the year round. During and shortly after heavy downpours the ground is temporarily flooded by rain water excess.

II. A valley slope about 8 to 10 m above the ground. Deep, well drained, yellowish loamy — sandy soils are abundant.

III. A flat-topped upland ("Chapada") about 20 to 25 m above the low-lying ground described above. Soils are of the heavy yellowish latosolic type.

All 3 sites show some similar forest stratification characteristics. In detail, however, distinctive differences occur. The forest strata may be discriminated in the heterogenous forest plots under study, although stratification is often discontinous and vertically poorly defined. Considering the sites II (valley slopes) and III (flat-topped upland), emergente trees are fairly common and the average canopy is higher than that of site I (low-lying ground). The so-called substratum is often ill-defined and dominated by various palm species. Constituents form seldom a closed layer. The ground layer, predominated by tree seedlings and herbaceous plants, including some stemless palms, is well developed at site I, while in the rather scarce ground strata at sites II and III tree seedlings are the dominant part of the layer.

Sampling :

At each site, 3 trees of the above mentioned species were selected for study, 2 trees being of the ecodominant stratum (DBH 15-20 cm), 1 tree being a sapling. The trees were cut between 6 h and 9 h in the morning under favourable humidity conditions. Scattered reflection of leaves was measured at random all over the crowns immediately after felling. In addition, with some leaves overgrowth by fungi and algae had to be considered. The reflection rates of the barks were determined all over the stems and the main branches. Attention was also paid to stem-overgrowth by mosses, fungi, algae and green to yellow lichen, but orchids, bromeliads and trailing lianas were beyond the scope of this study. Another part of the wetted leaf and bark material was put into nylonnet bags and taken to the laboratory. Time delay was in the order of less than 2 hours. Additionally the barks were air-dried (2 days, about 25°C and 50% relative humidity) in order to find out whether there is a significant difference between wet and dry bark material.

Scattered reflection

Method :

The scattered reflection of the leaves and barks of the species stated above was studied with a reflection meter and a set of 3 colored glass filters (Schott filters : BG 12, range 3550 A — 5150 A; VG 9, range 4420 A — 6440 A; RG 2, range 6000 A — 7500 A, th = 1 mm) over a 99% magnesia-white normal. Approximate filter transmittancy curves are given in figure 1.

The scattered reflection readings were done with a highly sensitive galvanometer.

Results (leaves):

Mean scattered reflection was calculated for all leaf samples on both sides and under different spectral conditions. Results are presented in table 1.

species	normal	BG 12	VG 9	RG 2
leaves — upper side				
Çardeiro	25.4	27.6	19.1	33.3
Ucuúbas	25.5	27.3	18.8	32.6
Breus	24.6	27.5	18.6	32.7
Matá-matás	25.6	28.0	19.6	32.6
leaves — lower side				
Cardeiro	29.9	30.7	23.8	37.5
Ucuúbas	31.5	32.2	26.0	38.2
Breus	29.9	30.6	24.2	36.3
Matá-matás	29.3	30.4	23.3	36.5

Tab. 1 Mean scattered reflection of tropical tree-leaves (4species) on both sides, considering different spectral conditions (size of sample = 800 readings/species).

Considering the data given in table 1, the following conclusions may be justified:

1.) The mean scattered reflection of tropical tree-leaves (**upper side**) is obviously lower (about 12 — 22%) than that of tree-leaves (**lower side**) with regard to species and spectral conditions.

2.) The mean scattered reflection deviation from the normal of tropical tree-leaves (**upper side**) shows a distinct maximum at RG 2 (about 25 % higher than normal), a secondary maximum at BG 12 (about 10 % higher than normal) and a remarkable minimum at VG 9 (about 30 % lower than normal), being nearly the same for all species.

3.) The mean scattered reflection deviation from the normal of tropical tree-leaves (**lower side**) arrives at a peak in RG 2 (about 20 % higher than normal), normal-like conditions in BG 12 (about 3 % higher than normal) and a distinctive minimum in VG 9 (about 25 % lower than normal) with respect to all species.

4.) Wilting and decomposition processes of leaf matter as well as overgrowth by fungi and algae cause a fair scattered reflection deviation (about 10 %) from the non-affected leaf material.

Results (barks):

The mean scattered reflection of tropical tree-barks (4 species) was determined for different spectral conditions. The data are given in table 2.

species	normal	BG 12	VG 9	RG 2	condition
Cardeiro	24.0	22.5	19.4	29.6	moist
Ucuúbas	23.9	25.8	18.5	31.5	moist
Breus	23.2	21.9	18.6	28.6	moist
Matá-matás	26.3	28.1	22.6	33.2	moist

Tab. 2 Mean scattered reflection of tropical tree-barks (4 species) considering different spectral conditions (size of sample = 800 readings/species).

In addition to the material presented in table 2, the mean scattered reflection of dry and moist tropical tree-barks (2 species) was computed and presented in table 3.

species	normal	BG 12	VG 9	RG 2	condition
Cardeiro	24.0	22.5	19.4	29.6	moist
Cardeiro	24.1	23.2	19.5	29.5	dry
Ucuúbas	23.9	25.8	19.5	29.5	moist
Ucuúbas	24.5	25.5	20.9	31.7	dry

Tab. 3 Mean scattered reflection of dry and moist tropical tree-barks (2 species) with regard to different spectral conditions (size of sample = 100 readings/species).

From the data of table 2, the following conclusions may be drawn :

1.) The mean scattered reflection deviation from the normal of tropical tree-barks (4 species) shows a maximum at RG 2 (about 19 — 25 % higher than normal) and a distintive minimum at VG 9 (about 15 to 30 % lower than normal). At BG 12, scattered reflection shifts about 5 % from normal. In general, the scattered reflection of tropical tree-barks shows a considerable standard deviation in comparison to the leaf analyses stated above.

2.) While tropical tree-barks exhibit a remarkable scattered reflection shifting at different parts of the trees (stem and branches) already, an additional variation arises by overgrowth like mosses, fungi, algae, lichen et al.

With respect to data stated in table 3, the following conclusions may be justified :

1.) The mean scattered reflection deviation from normal has a peak at RG 2 (Cardeiro about 20% higher, Ucuúbas about 25 % higher than normal) and a definite minimum at VG 9 (Cardeiro about 25% lower, Ucuúbas about 15% lower than normal). For BG 12, Cardeiro deviates to lower rates than normal (3 — 6% lower), while Ucuúbas show an upward trend (6 — 8 % higher). In general, scattered reflection rates of dry or moist samples allow a fair, but not significant discrimination.

In addition to the results stated above, all experimental data were subjeted to frequency analyses. The data were grouped in 7 classes, creating a class intervall of 4% over the range of 14% to 43% scattered reflection rates. Absolute cell frequency of data material, i.e. leaf and bark analyses respectively, was calculated for all 4 species (Cardeiro 1, Ucuúbas 2, Breus 3, Matá-matás 4) as cumulative relative frequency and plotted on probability paper with respect to the different spectral conditions (Normal, BG 12, VG 9, RG 2). The graphs are presented in figures 2, 3 (leaves) and 4 (barks).

Results (leaves):

According to the scattered reflection graphs given in figures 2 and 3, a distinctive conformity in shape may be observed, although the graphs presented in figure 3 shift remarkably to the right, i.e. to higher reflection rates. As well spectral scattered reflection graphs may be easily discriminated, showing equal maximum (RG 2) — minimum (VG 9) pattern as stated above.

Results (barks):

On the other hand, the scattered reflection graphs presented in figure 4 verify the great spectral tolerance of the bark material. The graphs of BG 12 and RG 2 can be discriminated for all 4 species with difficulties only. VG 9 graphs, however, show a disdinct individuality of species, accompanied by a remarkable tolerance in spectral range. BG 12 and RG 2 scattered reflection values are distributed between 14 and 39 % almost at random, depending on overgrowth. VG 9 rates are distinctly reduced in range, but of fair individuality in reflection behaviour of species.

Conclusions :

All four broad-leaf trees, well known in the environment of Manaus prove a distinctive absorption peak at VG 9 and a considerable scattered reflection maximum at RG 2, i.e. reflection rates shift to red and near-infrared, while BG 12 values are fairly affected only. In consequence, at the forest strata under survey, i.e. the ecodominant stratum above all, multiple scattered reflection with a considerable red-fraction will influence all light-borne processes decisively. The high scattered reflection of broad-leaf trees is extremely significant in infrared photography, too.

Sunlight peaks in the green at about 5500 A. As quantum efficiency of green light is the same as that of red and blue, relatively high absorption of VG 9 is very important in photosynthesis. According to Loomis (1965) rather similar characteristics were found in comparative studies on chlorophyll solutions.

ABSTRACT

At 3 different rain forest sites of R.F.D., leaves and barks of 4 tropical tree species, i.e. Cardeiro, (Scleronema micranthum Ducke), Ucuúbas (Virola ssp.) Breus (Protium ssp.) and Matá-matás ((Eschweilera ssp.), were studied under natural conditions and in the laboratory. All four species show a considerable uniformity of mean scattered reflection rates, although the reflection of leaves (**upper side**) is distinctively lower than that of leaves (**lower side**).

Scattered reflection peaks at RG 2 for all species, while the absorption maximum is measured at VG 9, a fact, which is highly important for both photosynthesis and other light-borne processes.

All 3 filter ranges used are well discriminated in shape and amount on both sides.

On the other hand, the scattered reflection of barks is rather intricate. Natural differences in color and bark pattern as well as overgrowth with mosses, algae, fungi et al. cause a far-ranging, but leveled scattered reflection distribution for all species, considering different spectral conditions. Dry and wet bark analyses show no significant scattered reflection differences.

RESUMO

Folhas e casca de quatro essências tropicais foram estudadas em laboratório e em condições naturais em três sítios diferentes na floresta equatorial úmida, tendo em vista as suas propriedades óticas.

As espécies estudadas foram : Cardeiro (Scleronema micranthum Ducke), Ucuúbas (Virola ssp.), Breus (Protium ssp.) e Matá-matás (Eschweilera ssp.). Nas quatro espécies foi registrada considerável uniformidade nos níveis médios de reflexão difusa pelas folhas, se bem que a reflexão pela face superior fôsse consistentemente mais baixa que a reflexão pela face inferior das folhas. A reflexão difusa atinge o máximo a RG2 nas quatro espécies. O máximo de absorção foi registrado a VG 9, um fato importante para a fotosíntese e outros processos dependentes da radiação luminosa. Com os três filtros impregados foi obtida boa discriminação qualitativa e quantitativa em ambas as faces das folhas.

Por outro lado, a reflexão difusa pelas cascas é bastante intrincada. Diferenças naturais de coloração, forma e ocorrência de excrescenções, algas, fungos e liquens produzem variações na distribuição da reflexão difusa nas quatro espécies, consideradas diferentes condições expectrais.

Foi comparada a reflexão difusa pela casca sêca e pela casca úmida não tendo sido encontradas diferenças significativas.

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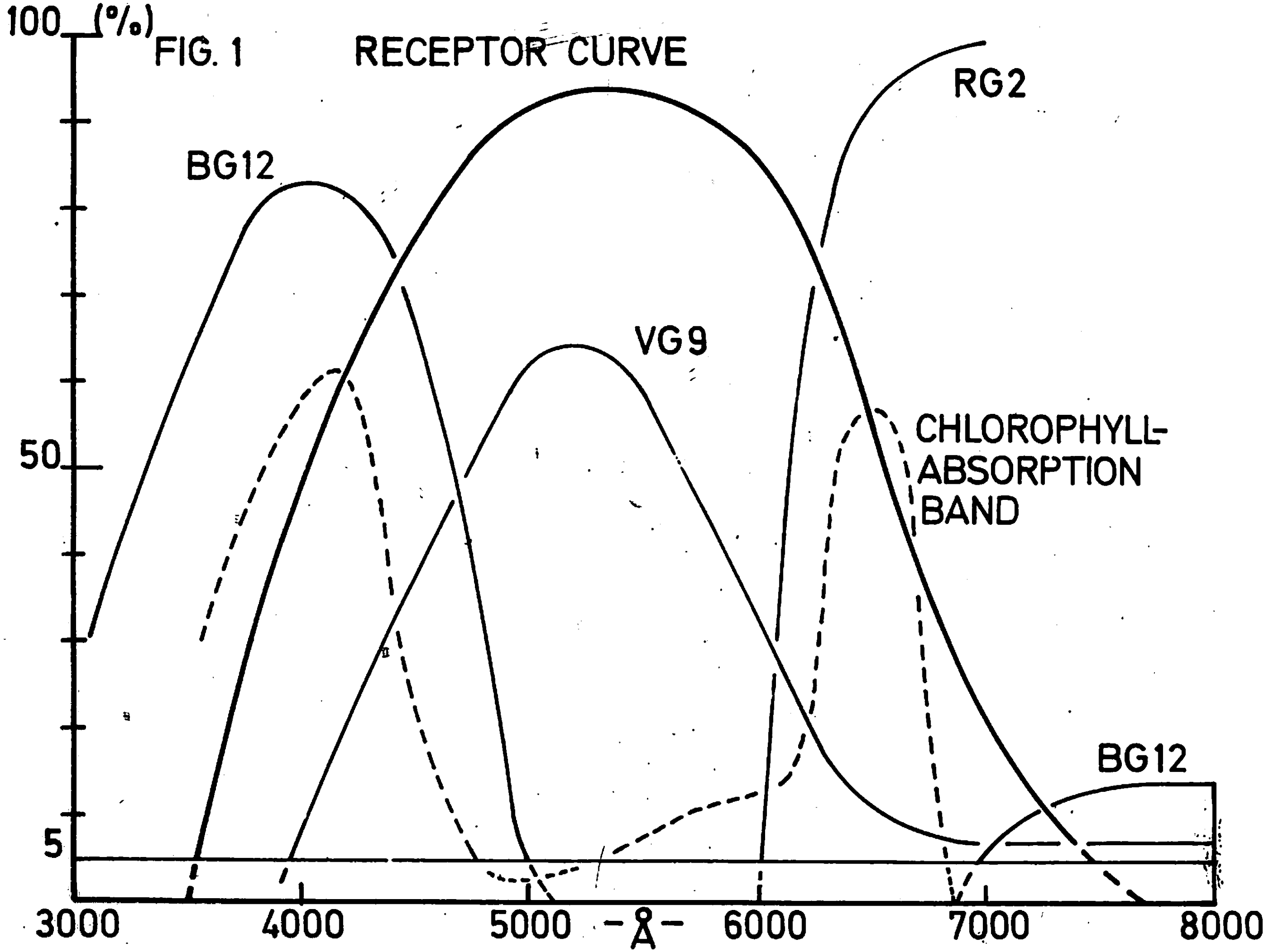
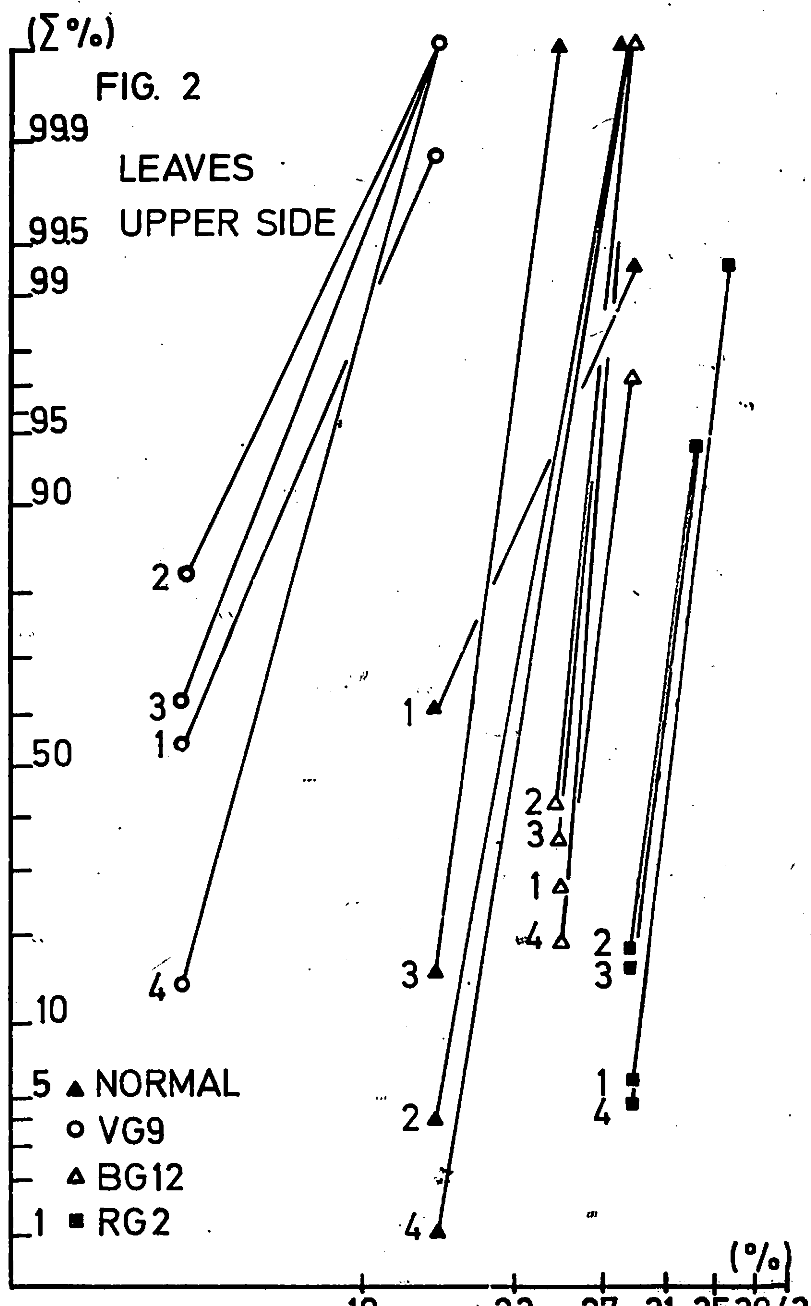
FIG. 1

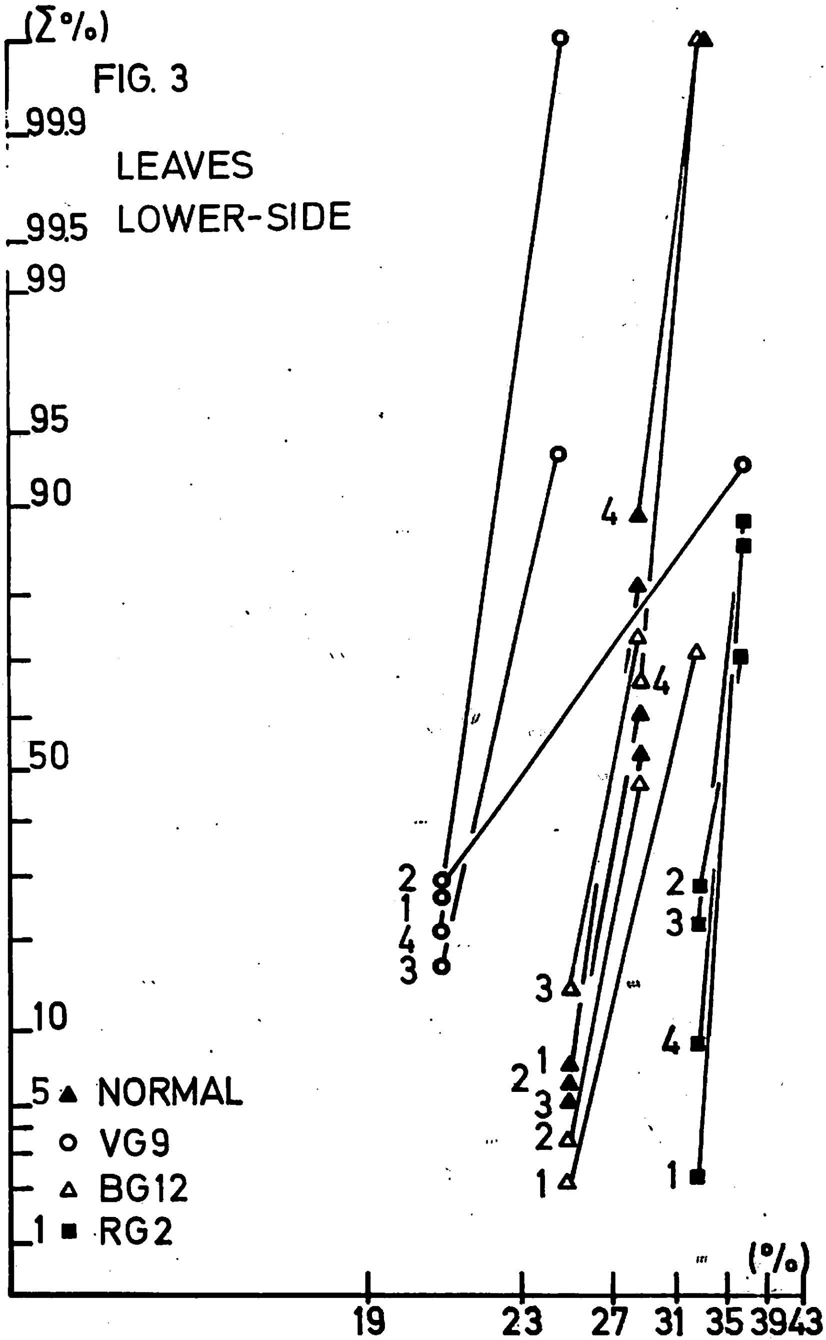


100 (%)
RECEPTOR CURVE
RG2
BG12
VG9
CHLOROPHYLL-ABSORPTION BAND
50
BG12
5
3000
4000
5000
-Å-
6000
7000
8000



(Σ%)
FIG. 2
LEAVES
UPPER SIDE
99.9
99.5
99
95
90
50
10
5
1
NORMAL
VG9
BG12
RG2
(%)
19
23
27
31
35
39
43

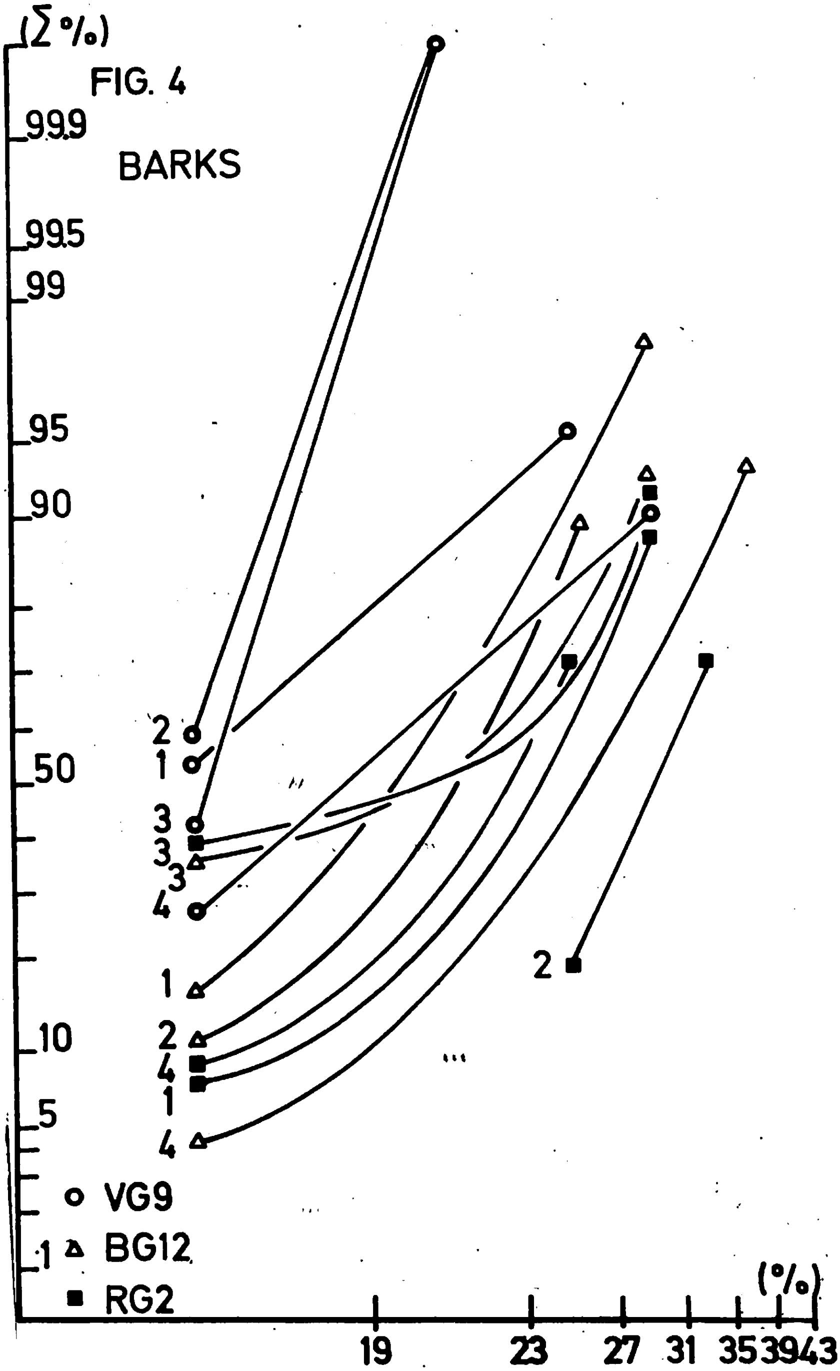
FIG. 3



(Σ%)
LEAVES
LOWER-SIDE
99.9
99.5
99
95
90
50
10
5
1
▲ NORMAL
○ VG9
△ BG12
■ RG2
(%)
19
23
27
31
35
39
43

FIG. 4

BARKS



(Σ %)
99.9
99.5
99
95
90
50
10
5
1
2
1
3
3
3
4
1
2
4
1
4
2
VG9
BG12
RG2
(%)
19
23
27
31
35
39
43

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